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SPECIFICATIONS
FOR
TWO HORIZONTAL DIRECT-ACTING
TRIPLE-EXPANSION SCREW-ENGINES,
SPECIAL PLAN NO. 2,
FOR
U. S. S. PHILADELPHIA.
(CRUISER NO. 4.)
OF ABOUT 4,300 TONS DISPLACEMENT.

DESIGNED AND TO BE BUILT BY

THE WM. CRAMP & SONS
SHIP AND ENGINE BUILDING CO.,
PHILADELPHIA.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1888.

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SPECIFICATIONS

FOR

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SPECIFICATIONS
FOR
TWO HORIZONTAL DIRECT-ACTING
Triple-Expansion Screw-Engines and Boilers
FOR
U. S. S. PHILADELPHIA.
(CRUISER NO. 4.)
OF 4,300 TONS DISPLACEMENT.

REFERENCE BEING HAD TO THE ACCOMPANYING DRAWINGS, WHICH
ARE TO FORM A PART OF THESE SPECIFICATIONS.

GENERAL DESCRIPTION.

The engines are to have, each, a high, intermediate and low-pressure cylinder, of 38, 56, and 86 inches diameter, respectively, and a piston-stroke of 40 inches.

The engines will be placed in separate water-tight compartments, and will be duplicates, the low-pressure cylinder being forward in the forward, and aft in the after compartment; the forward engine turning the port-propeller.

The main steam-valves are to be of the piston type; there will be one for the high-pressure, two for the intermediate, and two for each low-pressure cylinder, worked by radial valve-gear and arranged for a minimum cut-off of 0.4 of the stroke in the high-pressure and 0.5 in the intermediate and low-pressure cylinders.

Each piston is to have one piston-rod secured to a cross-head, which will run on guides, supported by the engine bed-frame.

Each crank-shaft will be built-up, made of steel, in one-piece, with cranks at equal angles and with the necessary coupling discs forged on.

The castings containing the crank-shaft bearings will be cast in five pieces for each engine. They will be bolted to engine keelsons, and stayed to cylinders by steel tie-rods and the engine bed-frames.

Each main engine will have two air and two bilge-pumps, all vertical and single-acting, driven by an independent compound engine. Also one centrifugal circulating pump to be arranged with bilge as well as sea-injection. Air-pumps to deliver into one feed-tank of boiler-iron. The tank will have a capacity of about 500 gallons, and will be partitioned and fitted as a filter.

The shells of condensers will be cylindrical and made of brass. They will be fitted with brass tubes $\frac{5}{8}$ inch diameter outside, and will have a total cooling surface of about 13,500 square feet measured on the outside of the tubes. The tubes will be placed fore-and-aft, the water circulating through them and thence overboard through outboard-delivery valves.

Suitable baffling and supporting plates will be arranged in each condenser to assist in the circulation of steam and to support the tubes.

There are to be two vertical duplex pumps fitted in each fire-room of ample capacity for feeding the boilers. One set in each fire-room will be fitted to draw from feed-water tank and bottom of forward condenser and discharge through boiler check-valves. The second set in each fire-room will be fitted to draw water from tank, sea, bilge, and boilers, and to discharge into fire-main, through boiler-checks, and overboard. The pump in forward fire-room to likewise discharge through distiller.

A horizontal pump is to be placed in each engine-room, and fitted to draw water from the sea and bilge, and to discharge into fire-main and through outboard-delivery.

The water-cylinders and chests of all pumps are to be of composition.

The distilling apparatus will be located where directed, and will consist of one distiller capable of furnishing 3,000 gallons of potable water in twenty-four hours. The circulating water for the distiller will be supplied by the auxiliary pump in forward fire-room.

The propellers are to be three-bladed, right and left-handed, respectively, of about 14 feet 6 inches diameter, and will be made of manganese-bronze.

There will be four double-ended horizontal return tubular boilers, containing an aggregate grate surface of 624 square feet, arranged fore and aft, in two water-tight compartments, with four athwartship fire-rooms. Each boiler will be 14 feet in diameter and about 20 feet long.

The smoke-pipe will be fixed, and its top will be about 60 feet above the grates.

Fire-rooms are to be arranged to work under air-pressure when required, and to be fitted, each, with two blowers, capable of supplying continuously, with ease, sufficient air for the required horse-power.

DETAILED DESCRIPTION.

CYLINDER CASINGS.

The cylinder casings, which will include the steam and exhaust ports and passages, inboard heads, and valve-chests, are to be of cast-iron.

They will be fitted with cylinder linings of hard cast-iron.

The cylinder casings will have extensions cast on them with flanges $1\frac{3}{4}$ inches thick for securing them to engine bed-frames.

The cylinder casings and covers, after being placed in the ship, are to be covered with non-conducting material, and neatly lagged with black walnut, removable where directed.

RECEIVERS.

The receivers will consist of the spaces between high-pressure and intermediate, and intermediate and low-pressure piston-valves and their connecting pipes.

There will be a $3\frac{1}{2}$ -inch copper pipe, with composition stop-valve, connecting main steam-pipe to each receiver space; and a composition safety-valve, with nickel seat of $2\frac{3}{4}$ inches diameter, on each receiver, the intermediate pressure weighted to 80 pounds per square inch above the atmosphere, and the low-pressure to 30 pounds.

CYLINDER LININGS.

The linings are to be of cast-iron as hard as tools can work, with central ring or rest. They will be $1\frac{1}{8}$ inches thick and will be accurately fitted and secured to the casings. They are to be smoothly and accurately bored to diameters of 38, 56, and 86 inches respectively, and for a piston-stroke of 40 inches. Cylinder linings to be jacketed.

CYLINDER HEADS AND COVERS.

The cylinder-heads are to be cast solid with cylinder casings and amply stiffened by ribs. They will have suitable openings for the stuffing-boxes. The cylinder covers are to be made of cast-steel and well-ribbed. Each low-pressure cover will have a man-hole cast in, which will be faced to receive the man-hole plate. The cylinder covers are to be faced true on the inside. They are to have faced flanges, and are to be secured to cylinder casings by wrought-iron bolts with finished nuts. Bolts are to be spaced not over 6 inches apart.

HOLDING-DOWN BOLTS.

All holding-down bolts for securing the engines in the ship are to be fitted with locked nuts.

MAN-HOLES AND PLATES.

The man-holes in low-pressure cylinder covers are to be 20 inches in diameter. The plates are to be turned to loosely fit the holes, faced on the inner surface to fit the facing-strip on cover or head, and to be finished on the outside.

VALVE-CHESTS AND COVERS.

The valve-chests will have openings at each end for inserting and removing the valves, and will be closed by single-plate covers of cast-iron, well ribbed, finished on outside with faced flanges $3\frac{1}{4}$ inches wide and $1\frac{3}{4}$ inches thick.

The inboard covers will contain the valve-stem stuffing-boxes; the outboard will serve as the valve-stem guide. The packing spaces will be fitted with metallic packing. The covers will be secured in place by 1-inch bolts, spaced not over 6 inches apart, and with finished wrought-iron nuts. Suitable bosses will be cast on the upper surface of steam-chests, directly over each steam-port, for the attachment of approved oil-cups.

VALVE LINERS.

The valve liners are to be made of cast-iron of the toughest quality, combined with a suitable degree of hardness. They are to be $\frac{7}{8}$ inch thick, accurately bored and turned; then forced into seats after the ports have been cut out $3\frac{1}{2}$ inches for H. P. and M. P., and $3\frac{5}{8}$ inches for L. P. The bridges in ports are to be $1\frac{3}{8}$ inches wide.

MAIN STEAM PISTON-VALVES.

The piston-valve will be made of composition, $\frac{5}{16}$ inch thick in the body of the valve.

Each end of all valves will be made steam-tight by two packing-rings of composition, $\frac{5}{8}$ inch square in cross section, cut obliquely, and held in place by a composition follower and wrought-iron bolts. The distance-pieces for separating the packing-rings at each end of the valves will be made of composition.

MAIN VALVE-STEMS.

The valve-stems will be made of steel, $2\frac{3}{8}$ inches diameter where they pass through the valves, and $3\frac{1}{2}$ inches diameter in the stuffing-boxes.

THROTTLE-VALVES.

The main steam-throttle for each high-pressure cylinder will consist of a disc-valve $15\frac{1}{2}$ inches diameter of opening, opening with the pressure in the steam-pipe, and operated by suitable gear with hand-lever adjacent to hand-lever of steam reversing-gear.

VALVE-GEAR.

The valve-gear is to be of the radial type. The cut-offs of all cylinders are to be capable of being adjusted independently of each other.

The distribution of steam in backward gear must be such as to permit the engines to be reversed quickly and to run astern at full power.

The eccentrics are to be made of cast-iron or steel. Each eccentric is to be made in two parts, securely fastened together by two mild-steel bolts. They are to be truly bored to fit the shaft and properly secured to the same. They are to be truly turned to a suitable eccentricity, and recessed at the sides to fit the flanges of the eccentric-straps.

Each eccentric-strap is to be in two parts, of cast-steel, with white-metal linings. The two parts are to be firmly fastened together by two mild-steel bolts with lock-nuts. The two parts of the strap are to be separated by suitable brass chipping-pieces. A prolongation of one part of each eccentric-strap will form the eccentric-lever.

Each eccentric-lever will carry two mild-steel pins, one with a hardened steel thimble securely fastened.

One of these pins to engage with the radius-link and the other with the valve-connecting-rod.

The movement of each valve is to be regulated by a reversing-arm and a radius-link.

Each reversing-arm is to be carried in bearings rising from the top of the corresponding crank-shaft bearing, with its main center line parallel to the axis of the crank-shaft, and in the same vertical plane. The reversing-arm with its journals to



be of cast-steel. A forged-steel pin is to be secured in the free end of the arm to engage with the radius-link. Each radius-link is to engage at one end with this pin and at the other with the lower pin on the eccentric-lever.

Each valve-connecting-rod will engage at one end with the corresponding pin in the eccentric-lever and at the other end with a pin in an arm on the valve-motion rock-shaft.

The valve-motion rock-shafts are to be carried in bearings bolted to the cylinder casings, and are to have arms set at suitable inclinations to each other by which the motion will be transmitted to the valve-stems by links.

The radius-links, valve-connecting-rods and valve-links are to be forged of mild-steel, finished all over.

All joint-pins are to be of steel.

All working bearings are to be of phosphor-bronze or other composition.

The reversing-arm bearings are to be cast on the main pillow-blocks. The valve-motion rock-shafts and arms and reversing-arms are to be of cast-steel.

The radius-links are to be capable of adjustment so as to preserve a constant distance between centers when taking up lost motion.

Fixed trammels are to be furnished, suitably protected from injury, for setting the radius-link centers to their proper distances.

The valve-stems are to be marked and furnished with fixed trammels for setting the valves without removing the valve-chest bonnets.

A spare set of bearings is to be furnished for all adjustable joints.

All parts of the valve-gear are to be suitably marked for convenience of putting together properly when overhauling.

REVERSING-GEAR.

Each engine will have a steam reversing-gear with the cylinder placed vertically. Each main engine is to have one hand-reversing lever, which is to be conveniently placed to be



worked from the working-platform. The reversing-lever sectors are to have adjustable stops to prevent the hand-levers being thrown beyond the full-ahead and astern positions.

The reversing-engines are to exhaust into the respective condensers.

STEAM-GOVERNOR.

There will be an efficient governor of an approved type, with all necessary connections fitted to the reversing-lever of each engine, so as to control the admission of steam to each cylinder for preventing racing in rough weather.

CYLINDER RELIEF-VALVES.

There will be an automatic relief-valve of not less than 3 inches diameter, located at each end of each cylinder; these valves to be guided by loosely fitting wings. They will be kept on their seats by the pressure of steam in their respective receivers and by a light spiral spring. The design of this detail to be approved before its construction.

CYLINDER DRAIN-VALVES.

There will be fitted to each end of each cylinder, as low as possible, a drain-valve of approved design, with 1-inch opening. These valves to be made of composition and to be flanged and bolted to bosses on cylinder-casings or heads. They are to be arranged to work by hand-levers at working-platform if found necessary.

PISTONS.

The pistons will be made of steel, the thickness of metal to be $2\frac{3}{4}$ inches at center and $1\frac{1}{2}$ inches at periphery; that around the eyes of the piston-rods to be $2\frac{3}{4}$ inches. Each piston will have one cast-iron wearing-shoe upon which it will rest. These shoes to be so fitted that they can be adjusted to take the wear. The packing-rings are to be $\frac{3}{4}$ inch thick, $\frac{5}{8}$ inch wide, and will be adjusted by steel springs of proper tension.



PISTON-RODS.

The piston-rods are to be of steel, finished $7\frac{1}{2}$ inches diameter, fitted and secured to the pistons by iron nuts. The piston-rods will be fitted into cross-heads and secured by nuts.

CYLINDER TIE-RODS.

The tie-rods securing the cylinders to pillow-block frames will be made of steel, turned to a diameter of $4\frac{3}{4}$ inches. They will have T-heads forged on each end. These rods will be secured to the pillow-blocks and to the cylinders by steel bolts $2\frac{3}{4}$ inches diameter.

PISTON-ROD STUFFING-BOXES.

The piston-rod stuffing-boxes will be formed in the cylinder-heads, and will be fitted with cast-iron bushings and glands. They will be fitted with an approved metallic packing.

CROSS-HEADS.

The cross-heads are to be of steel, finished all over, and fitted with cast-steel slippers, lined with white metal, 20 inches wide, 24 inches long. The connecting-rod journals are to be 9 inches diameter and 10 inches long.

ENGINE BED-FRAMES AND CROSS-HEAD SLIDES.

The engine bed-frames and cross-head slides will be of cast-steel, well secured to cylinders at one end and to the bed-plates at the other.

CONNECTING-RODS.

The connecting-rods are to be of steel, finished all over.

They will be 86 inches long between centers, 7 inches diameter of neck at crank-pin end, and 6 inches diameter of neck at cross-head end. The crank-pin and cross-head boxes will be made of composition. The crank-pin boxes to be secured to rod by two $4\frac{3}{4}$ -inch steel bolts, and each cross-head box by two $3\frac{3}{4}$ -inch bolts; the nuts to be secured by proper



set-screws. The boxes for crank-pins are to be $2\frac{1}{2}$ inches thick and for cross-heads $1\frac{3}{4}$ inches thick, accurately fitted to pins and rods.

CRANK-SHAFTS.

The crank-shaft for each set of engines will be made of steel, built-up with solid webs and couplings with cranks at equal angles. The shaft-journals will be $14\frac{1}{2}$ inches diameter and have a total length of about 122 inches.

The crank-webs will be $9\frac{1}{2}$ and $10\frac{1}{2}$ inches thick. The crank-pins will be 15 inches diameter and 17 inches long.

The couplings will be $3\frac{3}{4}$ inches thick and $28\frac{1}{2}$ inches diameter. The after, middle, and forward crank-pins and shaft-journals will have holes axially through them respectively 7, 8 and 9 inches diameter.

All journals, when finished, will be tested and their accuracy proved.

CRANK-SHAFT BOXES AND CAPS.

Boxes of composition will be fitted to the main pedestals. The caps are to be of steel and both boxes and caps are to be made with recesses for white-metal linings.

Each cap will have a hole through it of sufficient size to feel the journal. Each cap to be secured by two 4-inch steel bolts, and with set-screws to prevent nuts from working loose.

Composition boxes to be hollow for water circulation. Both shaft and crank-pin brasses will be scraped to accurately fit their journals.

BED-PLATES AND PILLOW-BLOCKS.

The bed-plates for pillow-blocks will each be made of steel in five castings, from which will spring the pedestals for crank-shaft bearings. The plates and pedestals will be cast hollow, with walls $1\frac{1}{8}$ and $\frac{7}{8}$ inch thick, the metal around the boxes to be $1\frac{3}{4}$ and 2 inches thick. The bottom flanges of bed-plates will be $1\frac{1}{8}$ inches thick and $3\frac{1}{2}$ inches wide.

SURFACE CONDENSERS.

The condenser-chests are to be cylindrical in form, "built-



up" of sheet-brass $\frac{1}{4}$ inch thick, amply sustained by angle and T-rings and composition flanges for the tube-plates.

The exhaust and discharge-nozzles, also the chambers for the circulating waters and the covers for the same, are to be of composition as thin and light as practicable, combined with ample strength and stiffness. The diameter of the exhaust opening will be 30 inches, and of the discharge openings to air-pumps 16 inches. The injection and delivery openings for the circulating water will be 15 inches in diameter. All flanges to be not less than $2\frac{1}{2}$ inches wide.

A 1-inch salt-water feed-valve will be attached to each condenser.

Each chest will contain 3,440 seamless-drawn brass tubes, $\frac{5}{8}$ inch outside diameter, of No. 20 B. W. G. thickness, spaced $\frac{1\frac{1}{8}}{16}$ of an inch between centers.

The exposed condensing length of tubes to be 12 feet, having a total cooling surface of 6,750 square feet. The tubes are to be thoroughly tinned inside and out, previous to the last drawing.

The tube-plates are to be of brass, $\frac{3}{8}$ inch thick, stayed to heads by eight 1-inch stays, bored or cored for the tubes, and counter-bored $\frac{7}{8}$ inch diameter and $\frac{9}{16}$ inch deep, the packing to be compressed by composition glands screwed into the plates, and to have device for preventing crawling of the tubes.

The tubes will be suitably supported by an approved system of composition diaphragm and deflecting plates in each condenser.

The condensers will be located behind the engine-cylinders and well secured in the ship.

Additionally, the condenser in the forward compartment will be fitted with straightway-valves in its cylinder exhaust-pipe, and discharge-pipe close to air-pump, for closing all communication with the main engines when the condenser is used for auxiliary purposes.

AUXILIARY EXHAUST-MAIN.

The auxiliary exhaust-main, where it passes through the



Each chest will have a nozzle of $3\frac{1}{2}$ inches diameter of opening under the valve for fire-pump suction.

Composition strainers equivalent in area to twice the area of valve will cover the openings through the ship.

BILGE-INJECTION.

A copper pipe of 12 inches internal diameter will connect each main injection-valve chest with the bilge in its engine compartment. Each pipe will have attached to it a composition non-return valve of 12 inches diameter of opening.

OUTBOARD-DELIVERY VALVES.

The chests, bonnets, seats, valves, stems and glands of outboard-delivery valves will be of composition.

The valves are to be fitted as checks, to open by pressure from inside, to cover openings through seats 15 inches diameter. Each chest will have a valve of $3\frac{1}{2}$ inches diameter of opening outside the main valve for the bilge discharge from fire-pumps, and one for the discharge from main bilge-pumps.

SEA-VALVES.

There are to be two sea-valves of not less than $3\frac{1}{2}$ inches diameter of opening in each fire-room, one to be used for blow and the other for sea-suction.

The chests are to be provided with suitable nozzles for connecting them with pipes, leading to boilers and pumps.

The chests, bonnets, valves, seats, stems, glands and hand-wheels are to be made of composition.

The suctions are to have composition strainers, with holes through them of an aggregate area not less than twice the area of valve openings.

FEED AND AUXILIARY-PUMPS.

There are to be two vertical duplex-pumps of approved design, located in each fire-room; each pump to have water-cylinders of 5 inches diameter and a piston-stroke of 12 inches. One pump in each fire-room to be connected to feed-tanks,



bottom of forward condenser, and boiler-checks only, and to have a screw check-valve on both suction and delivery-pipes close to the pump. The other pump in each fire-room to be fitted to draw from feed-tank, sea, bilge and boilers; and to deliver water into any of the boilers by a distinct set of feed-pipes and check-valves independent of the main feed system, and, likewise, into the fire-main and overboard.

In addition, the forward auxiliary pump is to be fitted with a suitable discharge-pipe for flushing the head and for distilling purposes. It will discharge its water overboard through a sea-valve forward.

FIRE AND BILGE-PUMPS.

There will be a vertical steam-pump of approved design placed in each engine-room. They will be fitted with the requisite valves and connections for use as bilge and fire-pumps, and draw water from the sea through a valve or main injection-chest or through bottom of ship and from the bilge. They will deliver overboard through valves on outboard-delivery valve-chests, and into fire-main.

Each pump will have a steam-cylinder of 8 inches diameter, water-cylinder of 5 inches diameter, and a stroke of 12 inches.

DISTILLER AND PUMP.

The distilling apparatus will be located on the berth-deck where directed, and will consist of one distiller of approved design capable of furnishing 3,000 gallons of potable water in 24 hours. It will take its steam from the auxiliary boiler by an independent stop-valve and pipe.

The auxiliary pump in fire-room will be used as a circulating-pump for the distiller. One independent pump for distiller.

The circulating water, after passing through the distiller, will go forward through a proper copper pipe for use in flushing the heads; a copper bye-pass pipe, fitted with suitable valves, will connect the discharge of the pump used to circulate water through the distiller with the pipe leading forward to the head, for use when from any cause the distiller is shut off.



The distiller to be fitted with a filter and with the pipes necessary for running the distilled water into the fresh-water tanks.

PUMP-CYLINDERS.

The water-cylinders of all steam-pumps will be made of composition.

All pumps will have screw check-valves in suction and delivery-pipes close to pump-chambers, and stop-valves in both steam and exhaust-pipes. All suction-pipes leading to bilge, excepting those from the circulating-pumps, are to be fitted with Macomb bilge-strainers. The steam-cylinders of all pumps, blowers, and other auxiliary machinery will have their exhaust-nozzles connected to an exhaust-main, which will pass through engine and fire-rooms. This main will be connected to both main condensers and to the second receivers of both engines, will also have a discharge into the atmosphere, and will be furnished with the necessary valves for governing the direction of the exhaust. Additionally, the main feed-pumps will be supplied with means of turning their exhaust steam into their feed suction-pipes.

WORKING-PLATFORMS.

Working-platforms of wrought-iron will be situated below the center of shaft and on each side of the bulkhead, between the engines, convenient to which will be arranged all the handles, levers, and connections for operating the engines, with the counters, revolution-indicators, clocks, steam and vacuum-gauges in plain view.

Ladders will be provided as means of escape from engine-rooms when the water-tight doors are closed, and will be located on the bulkhead separating the engine compartments.

The engine-room stairway for ordinary use will be accessible from the berth-deck through a door in engine-room hatch bulkhead, and will have its landing on the working-platform in the forward engine compartment. A door near this stairway will





communicate with after engine compartment, and suitable footways will be arranged for access to the moving parts of the machinery, fitted, where required, with brass hand-rails and finished wrought-iron stanchions.

FEED-WATER TANKS.

A feed-water tank will be placed in forward engine-room. It will be made of wrought-iron not over $\frac{3}{16}$ inch in thickness, and will have a capacity of about 500 gallons, and will be fitted as a filter and be provided with a vapor-pipe, a float-valve for preventing access of air to feed-pump, an overflow-pipe and a glass gauge.

A supply-pipe will lead from this tank to the main feed-pumps in fire-rooms.

LINE-SHAFTING.

The line and thrust-shafting of both engines will be made of steel, $13\frac{3}{4}$ inches diameter, with a 6-inch hole axially through it, and will be supported by spring bearings where necessary. The thrust-shafts will have eleven raised collars $1\frac{3}{4}$ inches thick, 18 inches outside diameter, and $1\frac{1}{4}$ inches space between them.

PROPELLER SHAFTING.

The propeller-shaft of each engine will be made of steel in two lengths. The forward length will be $14\frac{1}{2}$ inches outside diameter, with 8-inch hole axially through it. The after length will be 15 inches outside diameter with 9-inch hole axially through it. The hole will be reduced at propeller end to correspond with diameters. The forward length will be cased with brass in stern-pipe. The after length will be covered at bearing only. Sleeves at bearings $\frac{1}{8}$ inch thick, remainder $\frac{1}{2}$ inch thick.

SCREW-PROPELLERS.

The propellers are to be made of manganese-bronze, about $14\frac{1}{2}$ feet diameter; to have adjustable blades of such form and pitch as may be required, and to turn outward in forward motion.

OUTSIDE AND STERN-PIPE BEARINGS.

The stern-pipes and outside bearings will have composition bushings fitted with lignumvitæ staves, with the proper flanges for securing them in position.

The bearings in stuffing-boxes to be about 24 inches long, the outer ones about 32 inches and those in hangers about 48 inches.

All lignumvitæ is to bear on end of grain.

STERN-PIPE STUFFING-BOXES.

The stuffing-boxes are to be made of composition, with a packing space 1 inch wide and 6 inches deep, fitted with followers made in two parts with a space of $1\frac{1}{2}$ inches between them, and properly secured in place by Tobin's-metal bolts.

THRUST-BLOCKS AND BEARINGS.

The thrust-blocks and caps are to be of cast-iron, lined with white metal, and made for a circulation of water through them. They will be provided with stuffing-boxes and glands at both ends for retaining the oil.

The caps are to be made with lugs locking into the blocks, and will have ample oil and grease-cups with hinged covers.

Each cap will be well secured in place by four wrought-iron bolts $1\frac{1}{2}$ inches diameter.

The blocks will rest on sole-plates riveted to the foundations built in the ship, to which they will be secured by twelve bolts $1\frac{1}{2}$ inches diameter, and fitted with keys so that they can be accurately adjusted to line in any direction.

SPRING-BEARINGS.

Spring-bearings are to be at least 18 inches long.

TURNING-GEAR.

A suitable steam-gear is to be provided for turning the main engines.



WATER-PIPES.

Seamless brass water-pipes 2 inches diameter are to be fitted, with the necessary valves in each engine-room. The water to be supplied from a pump.

They will have two branches of not less than $1\frac{1}{2}$ inches diameter to each main and crank-pin bearing, one branch of 1 inch diameter to each eccentric, and two branches $1\frac{1}{2}$ inches diameter to each thrust-bearing.

Also two of $\frac{3}{4}$ inch diameter, screwed into each crank-shaft pillow-block, with holes leading down through brasses to tops of journals, and one of $\frac{3}{4}$ inch diameter screwed into each cross-head slide.

All branch water-pipes will be fitted with cocks or valves for regulating the supply of water to bearings.

JOURNAL-BOXES.

All journals or moving parts of iron or steel are to run in boxes either of composition or of cast-iron or steel lined with white-metal.

The crank-pin and crank-shaft boxes are to be lined with Parson's white-metal.

INDICATOR FITTINGS AND MOTIONS.

Indicator connections for each end of each steam-cylinder are to be fitted, as near as possible, to the bores of their cylinders, and so located as to be easily accessible.

The indicator-motions are to be so designed as to give the indicator-barrels motions coincident with those of the pistons, and of sufficient throw to give a diagram of 4 inches length.

REVOLUTION-INDICATORS.

Revolution-indicators, showing on suitable dials the speed and direction of the engines, are to be placed in each engine-room, and suitable dials for showing in which direction the engines are turning are to be placed in such part of the ship, on deck, as may be required.



OIL-CUPS.

Each crank-pin will be fitted with a telescopic or wiping arrangement, to be of approved design. All crank-shaft bearings will have ample oil-cups with hinged covers, tube and wick-holders, and so arranged that the amount of oil passing down each tube to the journals can be seen and regulated. Wipers carried by the upper ends of the eccentric-levers are to furnish oil for lubricating the eccentrics and all connections of the eccentric-levers. These wipers to take oil from strips of webbing or other approved device, supplied by oil-cups suitably supported and capable of adjustment so as to feed oil in all positions of the valve-gear, and also so arranged as to make the supply of oil to the various parts independently adjustable.

All other joints or moving parts not otherwise referred to, and especially the cross-head slides and the valve connections, are to have finished brass automatic oiling-gear of approved design, capable of supplying sufficient lubrication while the engines are in operation without waste of oil.

All oil-cups to be such as can be easily filled while the engines are running at maximum speed, and to have an oil capacity for at least four hours running.

All fixed bearings to have drip-cups cast on where possible, otherwise to be made of cast-brass and properly fitted.

All such cups to have drain-pipes and cocks of at least $\frac{1}{2}$ inch diameter, which can be used while the engines are in operation.

All moving bearings are to have drip-cups or pans of sheet-brass where necessary.

HOLES THROUGH SHIP.

All holes through the ship are to be covered by cocks or valves on the inside, and to be fitted with zinc protecting-rings if required.

PUMP CONNECTIONS TO FIRE-MAIN.

The fire and auxiliary feed-pumps will each have a discharge-pipe, with straight-way stop-valve, connecting it with the fire-



main running fore and aft, and a branch from each discharge-pipe near the pump will be fitted with standard hose-connections and straightway-valve.

EYE-BOLTS.

Wrought-iron eye-bolts and traveler-bars are to be properly located and secured wherever required for lifting different parts of machinery, and particularly the covers of cylinders and valve-chests, the covers of air and circulating-pumps and their valve-chests, the condenser-bonnets, the connecting-rods, the caps of pillow-blocks of crank-shaft and line-shaft journals and of thrust-bearings.

SECURING ENGINES IN SHIP.

The engines will be adjusted and lined upon the engine-keelsons, and when accurately in line the spaces around holding-down bolts between sole-plates and keelsons will be filled by accurately fitting wrought-iron washers, upon which the holding-down bolts will be set up and locked in place.

DRAIN-PIPES AND TRAPS.

All receptacles where condensed steam is likely to accumulate will be provided with drain-pipes and cocks of ample capacity leading to automatic traps (fitted with bye-pass pipes and valves), which will discharge into feed-tanks.

The drain-pipes from safety-valves are to be connected at least $\frac{1}{2}$ inch below the level of valve-seats.

BOILERS AND ATTACHMENTS.

There are to be four double-ended horizontal return tubular boilers, constructed of open-hearth steel. The boilers are to carry a working pressure of 160 pounds by gauge.

All plates are to be planed on their edges, and thoroughly calked inside and out wherever accessible. Butt-jointed seams are to be covered with straps, and all rivet-holes are to be



drilled to full size. Each boiler is to be 14 feet mean diameter outside, and about 20 feet long, and to have eight furnaces 36 inches least internal diameter.

GRATE-SURFACE.

Total grate-surface in four boilers 624 square feet.

GRATE-BARS.

The grate-bars to be of wrought-iron, in two lengths, of approved pattern. The furnace-fronts, bridge-walls, and bearers to be properly fitted to support the bars.

TUBES.

Each boiler is to contain about nine hundred and sixty-four lap-welded wrought-iron tubes. Every third tube, vertically and horizontally, is to be a stay-tube, and will be No. 8 B. W. G. thick and $2\frac{1}{4}$ inches external diameter. The other tubes will be No. 12 B. W. G. in thickness, $2\frac{1}{4}$ inches external diameter.

The stay-tubes to be screwed into both heads, the ends at front heads to be swelled. They will be expanded into both heads and beaded over at combustion-chamber ends. This method of setting is subject to change if so directed.

BOILER-SHELLS.

The shells are to be of plates $1\frac{1}{8}$ inches thick, the longitudinal joints to be double-strapped and double-riveted each side of seams. The circular joints to be lap-jointed and double riveted.

TUBE-SHEETS.

The tube-sheets are to be $\frac{9}{16}$ inch in thickness, and are to be accurately drilled for the tubes.

BOILER-HEADS AND BRACES.

The upper portion of the heads are to be $\frac{7}{8}$ inch thick and the lower portion $\frac{9}{16}$ inch thick. The upper portions of heads



will be braced by three rows of steel stays $2\frac{1}{2}$ inches diameter in the body, 17 inches between centers horizontally, and 13 inches vertically. Jaw-braces to be of iron. The tops of combustion-chambers to be stayed to shell by $1\frac{3}{4}$ -inch iron braces with crowfeet on top of the chambers, placed $6\frac{1}{4}$ inches apart in length of boiler and 13 inches in the diameter. All steel braces to be without welds in length or eyes. The through braces will be made with nuts on both sides of boiler-heads, having raised threads on ends.

FURNACES.

The furnaces are to be of the best steel, welded at joints, and corrugated. They are to be 36 inches diameter at the inside of corrugation, $\frac{1}{2}$ inch thick, and are to be single-riveted at their junction with front heads and combustion-chambers. Ash-pans of $\frac{1}{4}$ -inch wrought-iron will be fitted in all furnace-flues reaching from front to bridge-wall.

BRIDGE-WALLS.

A bridge-wall of approved pattern will be fitted in each furnace. The upper part will be finished with fire-brick. The bridge-walls to be easily removable.

COMBUSTION-CHAMBERS.

The combustion-chambers are to be about 54 inches deep; the sides, tops, ends, furnace-plates and tube-sheets to be $\frac{3}{16}$ inch thick. The sides to be stayed by steel screw stay-bolts $1\frac{1}{4}$ inch diameter, spaced not over $6\frac{3}{4}$ inches from center to center.

SMOKE-BOXES AND UPTAKES.

The smoke-boxes and uptakes are to be made with single shell, covered with an approved non-conducting substance and protected by an outside shell. The inner shell to be secured to boilers by $2\frac{1}{2}$ -inch angle-irons; angle-irons elsewhere to be 2 inches. Both shells to be made of iron $\frac{3}{16}$ inch and $\frac{1}{8}$ inch thick, respectively.



The connection doors are to be made of wrought-iron with double shells, and fitted with hinges and catches of wrought or malleable iron. The outside shell is to be $\frac{3}{16}$ inch thick, and the lining $\frac{1}{8}$ inch thick.

FURNACE-FRONTS.

The furnace-fronts are to be of wrought-iron $\frac{3}{8}$ inch thick, with cast-iron perforated liners.

FURNACE-DOORS.

The furnace-doors are to be of wrought-iron $\frac{1}{4}$ inch thick, with cast-iron perforated liners.

ASH-PIT DOORS.

The ash-pit doors are to be of wrought-iron $\frac{1}{8}$ inch thick, flanged 1 inch deep, and fitted to place so as to thoroughly close the ash-pits, and to fit lugs on bulkhead when not in use.

SADDLES.

Each boiler is to rest on three saddles which are to be built in and form part of hull. The boilers are to be secured by double angle-irons riveted to saddles and bolted to boilers.

SMOKE-PIPES.

There are to be two smoke-pipes 60 feet in total height above the upper grates. They are to be 6 feet 9 inches in diameter, made of wrought-iron plates; the lower course to be No. 7 B. W. G. thickness, the upper ones No. 8. The pipe is to be stiffened by flat bands on the inside, at top and bottom, and by a band 4 inches wide and 1 inch thick on outside at top. The pipe will be inclosed its entire length by a jacket, leaving an annular space of at least 3 inches. The jacket to be of wrought-iron, No. 13 B. W. G. thick, and to be covered by a hood with sufficient space for the escape of hot air. The pipe and jacket are to be made with strapped butt-joints. The smoke-box and breeching will be inclosed by a jacket made of



No. 16 iron. The pipe will be provided with stays, eyes and shackles, and will be supported in such a manner as to relieve the uptakes of its weight. A pivoted damper will be fitted in each smoke-pipe.

DRY-PIPES.

Each boiler is to have a properly perforated tinned-brass dry-pipe of reduced diameter at the internal end, but of same diameter at front end as the steam-pipe with which it is connected. It is to be placed as high as possible, and extend nearly the length of the boiler.

Its upper surface is to be pierced with holes $\frac{3}{4}$ inch in diameter, spaced equidistant, their aggregate area to be twice that of the cross-section of the pipe.

BOILER CLOTHING.

After the boilers are in place in the vessel and have been tested under steam, their shells and fronts are to be covered with approved material, which will be protected by a galvanized-iron covering, the joints of which will be lapped and bolted.

SAFETY-VALVES.

Each boiler is to have two automatic spring safety-valves 6 inches in diameter, adapted to a maximum pressure of 160 pounds per gauge, and fitted with proper levers and approved mechanism for working them from the fire-rooms. The chests, valves and stems are to be of composition, and seats of nickel or its equivalent.

The chests are to be bolted to stop-valve chambers, if possible, and connected by copper pipes to the escape-pipes, which will also be of copper. The seats of all safety-valves will be at least $\frac{1}{2}$ inch above the bottom of their chests.

SENTINEL-VALVES.

There is to be a sentinel-valve of $\frac{1}{2}$ square inch area attached to the front of each boiler, fitted with movable weight and



notched lever, and weighted to close tightly against a boiler pressure of 175 pounds per square inch.

STEAM-WHISTLE.

A composition steam-whistle, the bell of 8 inches diameter, is to be placed forward of the forward smoke-pipe, well above the level of the deck-awning, and connected with the main steam-pipe by a copper pipe having at its lower end a valve of appropriate kind and size, and a working-valve at upper end.

WATER-GAUGES.

Each boiler is to have two composition water-gauges carrying glasses 16 inches in exposed length, and with outside pipe-connections to top and bottom of boiler, the bottom of glass being 1 inch below the highest heating surface. The water-level to be marked on brass plate on outside of boiler.

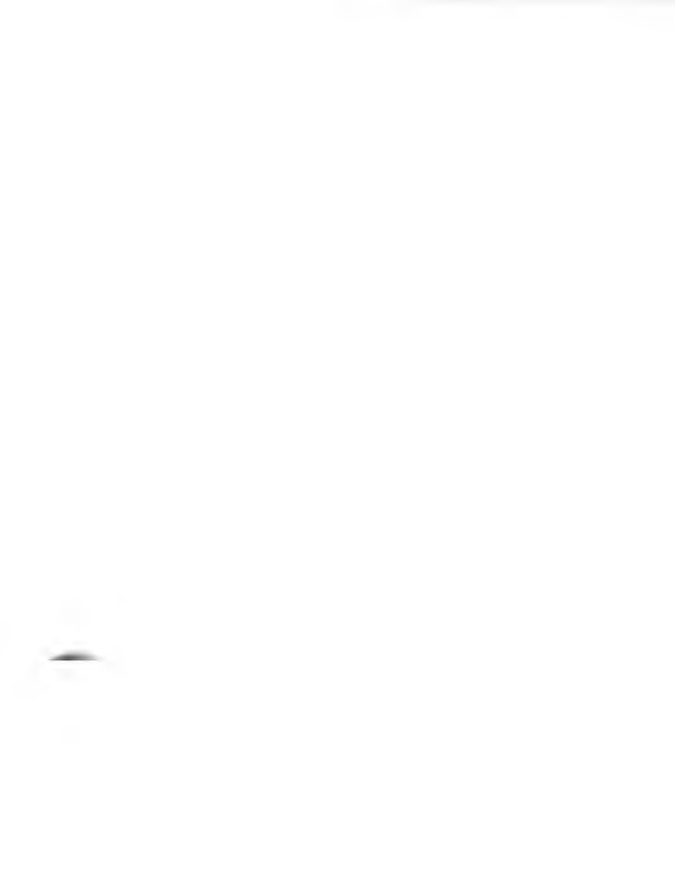
There shall also be four gauge-cocks on each end of boiler, placed 4 inches apart, the lowest cock to be placed 4 inches below the highest heating surface of the boiler. The cocks will be supplied with drip-pans and drain-pipes.

SALINOMETER-POTS.

There is to be a salinometer-pot of approved pattern for each boiler, fitted in an accessible position and suitably connected.

AUXILIARY BOILER.

There is to be one cylindrical horizontal return-tubular boiler for auxiliary purposes in after fire-room. It will be made of open-hearth steel for a working pressure of 160 pounds by gauge. The dimensions will be as follows: 8 feet 6 inches diameter, 8 feet 3 inches long, with two corrugated furnaces 2 feet 8 inches inside diameter, and 5 feet 10 inches long and $\frac{7}{16}$ inch thick. Shell-plates in one length $\frac{1}{8}$ inch thick, with double-riveted double butt-straps. The end plates above tubes to be $\frac{3}{4}$ inch thick and properly stayed. Remainder of plates $\frac{9}{16}$ inch thick. There will be 88 tubes 3 inches outside diameter. Smoke-boxes and uptakes to be similar to main boilers and smoke-pipe, to be carried into after main smoke-pipe.



TESTS.

Before being placed in the vessel all the boilers are to be tested under a pressure of 240 pounds by gauge,—this pressure to be obtained by the application of heat to water within the boilers, which are to be filled quite full. After a satisfactory test the boilers are to be painted on outside with two coats of brown zinc paint. Tests for cylinders will be for H. P. 175, I. P. 80, and L. P. 30 pounds. For condenser 30, tanks 15 and pumps 250 pounds.

AUXILIARY STEAM-PIPES AND VALVES.

Each boiler stop-valve chamber will have an auxiliary stop-valve 5 inches diameter, bolted to the nozzle on its side and under the main valve. These valves are to be connected by an auxiliary steam-pipe of 5 inches internal diameter, with suitable branches leading to the pumps, heaters, distiller and auxiliary engines.

A branch pipe with stop-valve will connect main and auxiliary steam-pipes in each engine-room.

A steam-gauge in brass case, with $4\frac{1}{2}$ -inch dial, will be attached to the auxiliary steam-pipe in each engine-room and each fire-room.

BLEEDER.

There is to be a copper pipe, with stop-valve at each end, 5 inches in diameter, leading from the main steam-pipe to each condenser. One valve in each engine-room to be worked from working-platform.

CHECK-VALVES.

Each boiler is to have two feed check-valves, $2\frac{1}{2}$ inches in diameter, having outside screw-threads on their stems; chambers, valves and stems to be made of composition.

All check-valves to have internal pipes.

BLOW-VALVES.

Each boiler is to have a bottom blow-valve of composition



2½ inches in diameter; also a surface blow-valve 1½ inches in diameter. These valves are to be connected by suitable pipes to the sea-valves.

The bottom blow-valves are to have internal pipes leading toward the bottoms of boilers, the surface blow-valves to have pipes leading to the centers of boilers, with openings about 1 inch above the highest heating surface.

FEED AND BLOW-PIPES.

The main feed-pipes are to be made of copper tubes, 2½ inches in internal diameter, and in sections not exceeding 12 feet in length. The blow-pipes to be 2½ inches in diameter. The branches to be of copper. All nozzles and flanges are to be of composition. The several sections are to be expanded into flanges, then turned over and brazed. All flanges to be united by forged bolts and nuts of Tobin's metal. Suitable provisions will be made for the expansion of these pipes.

BOILER STOP-VALVES.

The stop-valves will be non-return valves. Each boiler is to have a composition stop-valve chamber. The valve to be 11 inches in diameter, fitted with a screw-stem of composition, made to turn independently of the valve and to work in a composition nut supported by wrought-iron studs screwed into the cover. The valve is to be operated by a composition hand-wheel 16 inches in diameter. Separate provision is to be made for working all boiler stop-valves from above the protective-deck.

MAIN STEAM-PIPES.

The steam-pipes at stop-valves are to be 11 inches in internal diameter. The forward pair of boilers will be connected by a separate 15½-inch pipe to forward engines, the after pair by a 15½-inch pipe to after engines, these two pipes to be connected by a 15½-inch pipe. These pipes are to be of copper, the several sections to be united to each other and to the separators and valve-chambers by composition flanges of suitable size and thickness, riveted on and properly brazed. Where



FLOOR-PLATES.

The fire and engine-rooms and their passages are to be floored with wrought-iron plates having corrugations on the upper surface and proper ledges and drain-holes. They are to be of wrought-iron not less than $\frac{1}{4}$ inch thick, and all easily removable.

BLOWERS.

The fire-rooms are to be supplied with air by means of blowers, two to each fire-room. Each blower is to be driven by its own engines direct, and to be capable of supplying, with ease and certainty, sufficient air for efficient forced draught.

Each fire-room ventilator is to be so fitted that it can be easily closed from fire-room in case its blower is stopped.

VENTILATORS.

Two ventilators, each 24 inches in diameter, are to be fitted in each fire-room. They are to deliver air to the inlet of the blowers placed under them. They are to have movable hoods, and will be made of iron $\frac{1}{8}$ inch thick. The gears for turning the hoods will be of composition.

Four ventilators, 18 inches diameter, are to be fitted—two to each engine-room; they will lead down the engine-room hatches or as directed; their cowls will be worked from the engine-rooms. All ventilator-cowls will be made of copper No. 12 B. W. G., unplanned.

ASH-HOISTS.

There will be an ash-hoist arranged in ventilators for each fire-room, and a means for closing them when an air-pressure is required in the fire-room.

There will be an approved ash-hoisting engine for each fire-room, to hoist 150 pounds from fire-room floor to deck in five seconds with 60 pounds steam-pressure. They will be fitted with all necessary connections, including whip, and with a suitable brake to control the drum.

From each ash-hoist, on the upper deck, permanent over-

head rails, suitably supported, will lead to the nearest ash-chute on each side of ship. Each of these will be fitted with a traveler of approved design, with all necessary appliances for carrying the ash-buckets. At the top of each ash-chute a dumping-hopper will be fitted, so arranged as to fold up out of the way when not in use. The ash-buckets are to be balanced dump-buckets, with gear complete. All of the ash-hoisting and dumping gear is to be such that the buckets will not have to be lifted by hand. A speaking-tube will lead from the top of each ash-hoist to fire-room.

AIR-TIGHT FIRE-ROOMS.

Supplementary bulkheads and ceilings of light galvanized iron are to be fitted in the fire-rooms for the purpose of reducing the capacity of the space to be put under air-pressure. The ceiling is to be made movable beneath hatches. The vertical portion to be provided with openings where passage-ways are required, with suitable means for closing them.

All permanent and temporary joints and seams to be made perfectly air-tight.

HYDROKINETER.

There will be connected to each boiler a Wier's hydrokineter, or other approved appliance for circulating water in the boiler while raising steam, proper connections being made to auxiliary steam-pipe.

TESTS OF MATERIAL.

All material used in the construction of the boilers, crank-shafts, line, thrust and propeller-shafting, will be tested in accordance with the "Instructions to Inspectors," a copy of which is appended to these specifications.

DUPLICATE PIECES.

All duplicate pieces are to be finished and fitted ready for use. They are to be as follows, viz:

One set of valves and springs for each steam-pump.

One set, with guards and bolts complete, for receiving-valves, and one for delivery-valves of air-pump.



One-half set of follower-bolts and nuts for each steam-piston, and one-half set for each air-pump piston.

One set of brasses for each crank-shaft journal of each engine.

One set of brasses for each crank-pin.

One set of brasses for a cross-head journal.

One slipper for a cross-head.

One set of brasses for each adjustable connection of each valve-gear.

Three extra blades will be furnished for each screw-propeller, to be of such dimensions as may be required.

Two hundred condenser-tubes packed in boxes.

Fifty stay-tubes, threaded to fit threads in tube-sheets, and 100 plain boiler-tubes, annealed. The ends of stay-tubes to be wrapped in canvas. All boiler-tubes to be securely stowed in racks, or as directed.

One spare basket for each Macomb's strainer.

One-eighth of a set of grate-bars.

One complete set of brasses for each circulating-pump engine, each air-pump engine and each blowing engine.

One man and hand-hole plate of each size.

Fifty condenser tube-glands.

All duplicate pieces not of brass to be painted with three coats of white lead and oil, and well lashed in tarred canvas, with name marked in black paint on the outside.

Brass pieces to be marked or stamped.

OIL-TANKS, CANS, ETC.

Four oil-tanks of iron $\frac{1}{8}$ of an inch thick, with an aggregate capacity of 1,000 gallons, are to be well secured in oil store-room with facilities for filling them from deck. The tanks are to be strengthened by internal stays, if directed. Each tank will have a man-hole near the top closed by a plate, and will be fitted with a locked cock for drawing oil.

Four copper oil-tanks of 20 gallons capacity each, with lids and drip-pans, to be placed permanently in the engine-rooms in convenient positions, and to have a locked brass cock on each.

A copper oil-tank of 5 gallons capacity, with drip-pan, will be fitted in each fire-room.



An iron tallow-tank of 100 pounds capacity, with hinged cover, will be fitted in one engine-room.

INSTRUMENTS, TOOLS, ETC.

Twelve indicators of standard size and approved pattern, with proper attachments of finished brass, are to be furnished ready fitted; each indicator will be fitted with three springs graduated respectively to a scale of 80, 40 and 16 pounds to the inch, and with an extra cock attachment. A separate indicator stand-pipe is to be connected to each end of each main cylinder by a pipe of one inch diameter, having a cock of equal area of opening.

Two sets of instruments, with proper attachments, each instrument in its own case, which will be of brass, as follows, viz:

Two Lane's improved spring steam-gauges, 6-inch face.

One Lane's improved spring compound-gauge, 6-inch face.

One Lane's improved spring vacuum-gauge, 6-inch face.

One continuous counter, with positive motion, to register from 1 to 1,000,000.

One eight-day clock with second-hand.

One mercurial vacuum-gauge attached immediately to condenser.

The above list to be considered as one set.

There will be four Lane's improved spring-gauges, one for each boiler, with $8\frac{1}{2}$ -inch face, and graduated to 320 pounds.

Each gauge will be properly secured in the fire-room and have an independent connection to its boiler.

Eight thermometers, one for each hot-well or feed-tank, one in each outboard-delivery pipe, one for each injection and one for each steam-pipe close to the engines, to be made permanent fixtures, with their stems and bulbs protected by brass covers; also two spare steam-thermometers, two spare water-thermometers and one standardized thermometer in suitable case.

An engine-room telegraph of approved design, with reply-gongs and any number of dials that may be required, to be supplied and fitted for each pair of engines. Telegraphs of approved pattern are to be fitted to put engine-rooms and fire-rooms in communication.



A gauge of approved pattern will be fitted in each fire-room to show the excess of air-pressure over the pressure of the open atmosphere. A portable air-pressure gauge will also be supplied to each fire-room, with connections for attaching it to the furnaces, uptakes, and where directed, to measure the pressure as compared with the air-pressure in the fire-room. All of these gauges to indicate pressure in "inches of water."

A set of wrenches, fitting all nuts in fire-rooms, is to be supplied to each fire-room and placed in iron racks.

Fixed trammels or gauges are to be supplied for lining up crank-shafts horizontally and vertically, marks for this purpose being made on brass plates let into pillow-block frames.

Two complete sets of fire-irons for each fire-room, with suitable racks for stowing.

Lazy-bars for each boiler to be fitted in place.

One set of wrenches complete for each engine, to be fitted to all the nuts, finished and marked with size, and placed in iron racks. Wrenches for all nuts of bolts two inches in diameter and over to be box-wrenches, where such can be used.

One pair of taps, one rod, for tapping front and back tube-sheets at one operation. This to be a duplicate of the tool used in originally tapping the sheets, and to be packed so as to be perfectly protected from injury.

A steam tube-cleaner of approved design with fittings and connections complete. To be fitted with a wooden handle and stowed in a convenient rack in fire-room. A spare nozzle and flexible steam-pipe to be furnished.

Six ash-buckets.

Eight coal-buckets.

SCHEDULE OF THICKNESS OF COPPER AND BRASS
PIPES, B. W. G.

					Diam.	No.
Main and branch steam-pipes	-	-	-	-	15½"	0
					11"	3
					5"	8
					3"	11
Air-pump discharge	-	-	-	-		12



	No.
Circulating suction and discharge - - -	8
Bilge-suction and delivery, large pump - - -	12
Blow-pipes - - - - -	10
Main exhaust - - - - -	7
Main and auxiliary feed-delivery - - -	12
Main and auxiliary feed-suction - - -	14
Waste-steam pipes and auxiliary exhausts - - -	16
Dry-pipes - - - - -	14

All bends are to be made one gauge thicker than straight part of pipe.

Expansion-joints or bends are to be fitted to pipes wherever required.

AUXILIARY EXHAUST TO ESCAPE-PIPES.

Where the auxiliary exhaust-main is connected to the escape-pipes it will have two stop-valves, close together, for each connection.

ASH-SPRINKLERS.

There will be on athwartship bulkheads of fire-rooms, opposite each boiler, and about four feet from floor, a brass nozzle with universal joint, with valve and sea connections for wetting ashes. This to be of approved design and to be secured alongside bulkhead when not in use.

MANDRELS FOR WHITE-METAL BEARINGS.

Cast-iron mandrels are to be furnished for forming the linings of all bearings lined with white-metal. All these to be smoothly and accurately turned, and to be packed so as to be perfectly protected.

RADIATORS.

Steam-radiators of about 600 feet superficial area for the several parts of the ship will be provided.

Each radiator will be divided into as many separate and distinct parts as may be directed; each part to have its own steam and drain-valve. The steam and drain-pipes are to be



seamless-drawn brass, of iron-pipe size, suitably connected by composition elbows, tees, and unions in a manner that will enable them to be easily taken down for repairs.

There will be reducing-valves in these pipes at the boiler connections to regulate the pressure, and the drains will lead to such water-collectors as may be designated, or where preferred, overboard.

MATERIALS AND WORKMANSHIP.

All materials used in the construction of the machinery are to be of the best quality. The iron castings to be of the best pig-iron (not scrap). The brass castings to be made of new materials of best quality. Where Tobin's metal is specified, the composition to be 58.22 parts copper, 39.48 parts zinc, 2.30 parts tin. For all other brass-work, the composition to be 88 parts copper, 10 parts tin, and 2 parts zinc. All iron casting to be smooth, and true to form, and before being painted to be well cleansed of sand and scale, and all fins and roughness removed.

All boiler-plates to be thoroughly cleansed of oxide-of-iron scale. Brass castings to be sound, smooth and true. No imperfect casting or unsound forging will be used, if the imperfection affects the strength or, to a marked degree, its sightliness.

All flanged boiler-plates are to be annealed in an approved manner after flanging.

The steam-cylinders of all auxiliary engines are to be clothed and lagged the same as main cylinders.

All cocks are to have engraved brass plates to show their use and whether open or shut. All valve-wheels will be of composition, and will be plainly engraved to show their use, as will also all working levers and all gear for working valves from deck.

All steam, exhaust and other pipes leading to and from steering and other engines, distillers, and pumps are to be of sufficient size for their respective objects, and to have provision for expansion where directed.

All copper pipes not seamless-drawn are to be brazed, and all copper pipes are to be expanded into composition flanges, turned over and brazed.

All pipes passing through coal-bunkers will be cased in.

All pipes, not otherwise specified, to be of copper, and all pipes beneath floor-plates to be connected by forged bolts and nuts of Tobin's metal. All nuts on rough castings to fit facings. All pipes beneath floor-plates to be covered as directed, and care taken that they do not come in contact with the plates or frames of hull.

The work to be in every respect of the first quality, and executed in a workmanlike and substantial manner.

All flanges to be faced and grooved. All bolt-holes in permanently fixed parts to be reamed, and the body of the bolts to be finished to fit them snugly. All threads on bolts to correspond to the Navy standard. All brasses to fit loosely between collars of shafting.

All nuts on moving parts and on pillow-blocks to be thoroughly secured with keepers, pins, or steel set-screws. All brasses or journals to be properly channeled for the proper distribution of oil. All flanges coupled together to be faced, and edges made fair with each other. Metallic packing for stuffing-boxes to be such as may be approved.

The contractors for the hull will supply the labor to fit the engine and boiler keelsons to the engines and boilers, and similarly for all auxiliaries.

All parts of machinery and boilers are to be secured, in an approved manner, to prevent displacement when the vessel is used for ramming.

Any portion of the work, whether partially or entirely completed, found defective, must be removed and satisfactorily replaced without extra charge.

TESTS OF MACHINERY.

The cylinder-casings, condensers, and all tubes and pipes are to be tested for tightness before being placed in the ship.

